CT-2749-NP

UNITED STATES PATENT APPLICATION OF

YONG-JIN WU
228 Devonshire Lane
Madison, Connecticut 06443

LI-QIANG SUN
131 Lenox Drive
Glastonbury, CT 06033

and

JIE CHEN
14 Martleshamheath Lane
Madison, CT 06443

FOR

3-(PYRIDINYL-PIPERAZIN-1-YL)-PHENYLETHYL AMIDES AS POTASSIUM CHANNEL OPENERS

3-(PYRIDINYL-PIPERAZIN-1-YL)-PHENYLETHYL AMIDES AS POTASSIUM CHANNEL OPENERS

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a non-provisional application which claims the benefit of U.S. Provisional Application Number 60/428,354 filed November 22, 2002.

FIELD OF THE INVENTION

The present invention is directed to novel pyridinyl piperazinyl amide derivatives which are modulators of KCNQ potassium channels and are therefore useful in treating disorders responsive to the modulation of the potassium channels. The present invention also provides a method of treatment with the novel pyridinyl piperazinyl amide derivatives and to pharmaceutical compositions thereof.

BACKGROUND OF THE INVENTION

Potassium (K^+) channels are considered to be the most diverse class of ion channels and have several critical roles in cell function. This has been demonstrated in neurons where K^+ channels are responsible, in part, for determining cell excitability by contributing to membrane repolarization following depolarization, resting membrane potential, and regulation of neurotransmitter release. The M-current has long been described, by electrophysiology recording methods and by pharmacology, as a dominant conductance in controlling neuronal excitability. Pharmacological activation or suppression of M-currents by small molecules could have profound effects in controlling neuronal excitability. Recently, Wang et al., *Science*, 282:1890-1893, (1998) reported that co-assembly of the KCNQ2 and KCNQ3 potassium channels underlies the native M-current in neurons.

Activation or opening of the KCNQ channel(s), particularly the KCNQ2 or KCNQ2/3 channel(s), mutated or wild type, may prove to be beneficial in increasing hyperpolarization of neurons, thereby resulting in protection from abnormal synchronous firing during a migraine attack. The present invention

provides a solution to the problem of abnormal synchronous firing of neurons related to migraine headache by demonstrating that modulators, preferably openers, of KCNQ potassium channels increases hyperpolarization of neurons which protects against abnormal synchronous neuron firing involved in migraine attacks.

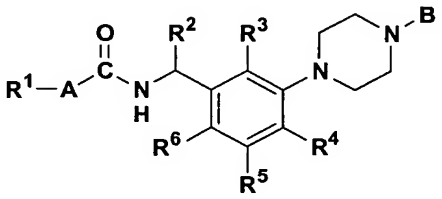
Although the symptom pattern varies among migraine sufferers, the severity of migraine pain justifies a need for vigorous, yet safe and effective, treatments and therapies for the great majority of cases. Needed in the art are agents that can be used to combat and relieve migraine (and diseases similar to and mechanistically related to migraine), and even prevent the recurrence of migraine. Also needed are anti-migraine agents which are effective in the treatment of acute migraine, as well as in the prodrome phase of a migraine attack. Thus, a clear goal in the art is to discover new, safe, nontoxic and effective anti-migraine compounds for use as drugs, and in anti-migraine compositions and treatments.

Because migraine afflicts a large percentage of the population, there is a need to discover compounds and agents that are useful in therapeutics and treatments, and as components of pharmaceutical compositions, for reducing, ameliorating, or alleviating the pain and discomfort of migraine headache and other symptoms of migraine. The present invention satisfies such a need by providing compounds that function as openers of the KCNQ family of potassium channel proteins to serve as anti-migraine agents or drugs and to comprise compositions to treat migraine, as described herein.

A broad range of cinnamide compounds are known and new compounds continue to be reported with a broad range of utility. Some of these compounds can be found in the disclosures of WO 00/07993 published February 17, 2000, EP 810220A1, published December 3, 1997, U.S.4,927,838 issued May 22, 1990 to Guthrie, et al., U.S.6,046,239 issued April 4, 2000 to Lennox, et al., WO 00.42013, published July 20, 2000, WO 01/10381 published February 15, 2001, WO 01/10380 published February 15, 2001, JP45-14291 published May 21, 1970, and JP2-138159 published May 28, 1990. The compounds described in these patents are distinct from those of the present invention.

SUMMARY OF THE INVENTION

The present invention provides piperazinyl phenylethyl amides and related derivatives having the general Formula I

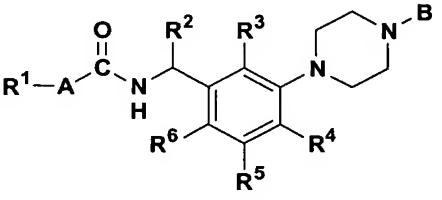


I

wherein R^1, R^2, R^3, R^4, R^5, R^6, A and B are as defined below, or a nontoxic pharmaceutically acceptable salt, solvate or hydrate thereof which are openers or activators of KCNQ potassium channels. The present invention also provides pharmaceutical compositions comprising said piperazinyl phenylethyl amides and to the method of treatment of disorders sensitive to KCNQ potassium channel opening activity such as migraine or a migraine attack, bipolar disorders, epilepsy, acute and chronic pain, and anxiety.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides novel piperazinyl phenylethyl amides and related derivatives which are modulators of the KCNQ potassium channels and which have the general Formula I or a pharmaceutically acceptable salt thereof



I

wherein R^1 is selected from the group consisting of pyridinyl, 3-quinolinyl, 2-thienyl, C_{3-6} cycloalkyl and phenyl optionally substituted with substituent independently selected from the group consisting of halogen, C_{1-4} alkyl, C_{1-4} alkoxy, trifluoromethyl and trifluoromethoxy; A is –CH=CH- or $-(CH_2)_n-$; R^2 is C_{1-4} alkyl, CF_3 or hydroxymethyl; R^3, R^4, R^5 and R^6 each are independently

hydrogen or fluoro; n is an integer of 1 or 2; and B is 2-pyridinyl, 3-pyridinyl or 4-pyridinyl.

The present invention also provides a method for the treatment or alleviation of disorders associated with KCNQ potassium channel polypeptides and, in particular, human KCNQ potassium channel polypeptides in a mammal in need thereof which comprises administering together with a conventional adjuvant, carrier or diluent a therapeutically effective amount of a compound of Formula I or a pharmaceutically acceptable salt thereof. Preferably, the compounds of Formula I are useful in the treatment of migraine or a migraine attack, cluster headaches, bipolar disorder, convulsions, mania, acute mania, epilepsy, anxiety, depression, schizophrenia, functional bowel disorders, stroke, traumatic brain injury, multiple sclerosis, neurodegenerative disorders or alleviating pain such as musculoskeletal pain, post operative pain, surgical pain, inflammatory pain, neuropathic pain such as diabetic neuropathy and pain associated with cancer and fibromyalgia.

The term "pain" as used herein and in the claims means all types of acute and chronic pain, such as neuropathic pain, post-operative pain, chronic lower back pain, cluster headaches, herpes neuralgia, phantom limb pain, central pain, dental pain, opioid-resistant pain, visceral pain, surgical pain, bone injury pain, pain during labor and delivery, pain resulting from burns, including sunburn, post partum pain, migraine, angina pain, and genitourinary tract-related pain including cystitis and the term also is intended to include nociceptive pain or nociception.

The term "C_{1-4} alkyl" as used herein and in the claims means straight or branched chain alkyl groups such as methyl, ethyl, propyl, isopropyl, butyl, isobutyl, and *tert*-butyl. The term "C_{1-4} alkoxy" as used herein and in the claims means an oxygen substituted with straight or branched chain alkyl groups and includes groups such as methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy, and *tert*-butoxy. The term "halogen" as used herein and in the claims is intended to include bromine, chlorine, iodine and fluorine.

As the compounds of the present invention contain a substituted carbon-carbon double bond as part of the structure, the compounds of the invention exist in either of two geometric isomeric forms, namely as cis or trans isomers.

Preferred are the trans isomers in which the group R^1 and the amide group, C(O)NH, are trans to each other when A is –CH=CH-. As the compounds of the present invention possess an asymmetric carbon atom, such as the carbon adjacent to the amide nitrogen and to which the phenyl is attached, the present invention includes the racemate as well as the individual enantiomeric forms of the compounds of Formula I as described herein and in the claims. Preferred embodiments of compounds of Formula I include the racemate, a single enantiomer, and in certain instances a single enantiomer wherein the carbon adjacent to the amide nitrogen and to which the phenyl is attached has the *(S)* stereochemistry. Mixtures of isomers of the compounds of Formula I or chiral precursors thereof can be separated into individual isomers according to methods which are known per se, e.g. fractional crystallization, adsorption chromatography or other suitable separation processes. Resulting racemates can be separated into antipodes in the usual manner after introduction of suitable salt-forming groupings, e.g. by forming a mixture of diastereosiomeric salts with optically active salt-forming agents, separating the mixture into diastereomeric salts and converting the separated salts into the free compounds. The enantiomeric forms may also be separated by fractionation through chiral high pressure liquid chromatography columns, according to procedures described herein.

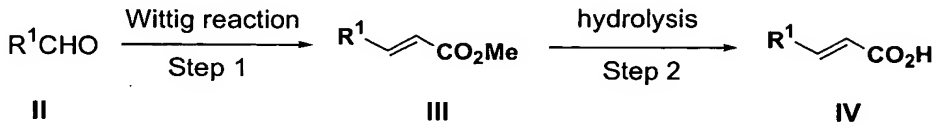
Certain of the compounds of the present invention can exist in unsolvated forms as well as solvated forms including hydrated forms such as monohydrate, dihydrate, trihydrate, hemihydrate, tetrahydrate and the like. The products may be true solvates, while in other cases, the products may merely retain adventitious solvent or be a mixture of solvate plus some adventitious solvent. It should be appreciated by those skilled in the art that solvated forms are equivalent to unsolvated forms and are intended to be encompassed within the scope of the present invention.

In the method of the present invention, the term "therapeutically effective amount" means the total amount of each active component of the method that is sufficient to show a meaningful patient benefit, i.e., amelioration or healing of conditions which respond to modulation of the KCNQ potassium channels.

When applied to an individual active ingredient, administered alone, the term refers to that ingredient alone. When applied to a combination, the term refers to combined amounts of the active ingredients that result in the therapeutic effect, whether administered in combination, serially or simultaneously. The term "KCNQ" as used herein and in the claims means the family of KCNQ2, KCNQ3, KCNQ4, and KCNQ5 potassium channel polypeptides as well as heteromultimers of different individual family members which include but are not limited to KCNQ2/3, KCNQ2/5 and KCNQ3/5. The terms "treat, treating, treatment" as used herein and in the claims means preventing, alleviating or ameliorating diseases and/or symptoms associated with dysfunction of cellular membrane polarization and conductance of human KCNQ2, KCNQ3, KCNQ4, and KCNQ5 potassium channel polypeptides and, in particular, migraine and/or symptoms that precede a full-blown migraine attack, neuropathic pain, mania and anxiety.

The general procedures used to synthesize intermediates and the compounds of Formula I are described in Reaction Schemes 1-4 and are illustrated in the preparations and examples. Reasonable variations of the described procedures, which would be evident to one skilled in the art, are intended to be within the scope of the present invention.

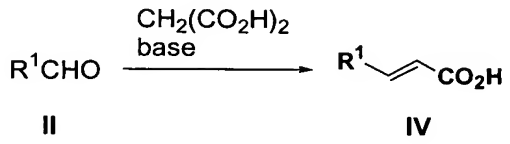
Reaction Scheme 1



Reaction Scheme 1 depicts the preparation of cinnamic acid derivatives useful as intermediates in the synthesis of compounds of Formula I. Step 1 of Scheme 1 depicts the Wittig reaction of an appropriate aldehyde of Formula II with an appropriate Wittig reagent to provide the methyl ester of Formula III. Hydrolysis of the methyl ester of Formula III can be accomplished using an appropriate base such as sodium hydroxide or lithium hydroxide in an appropriate

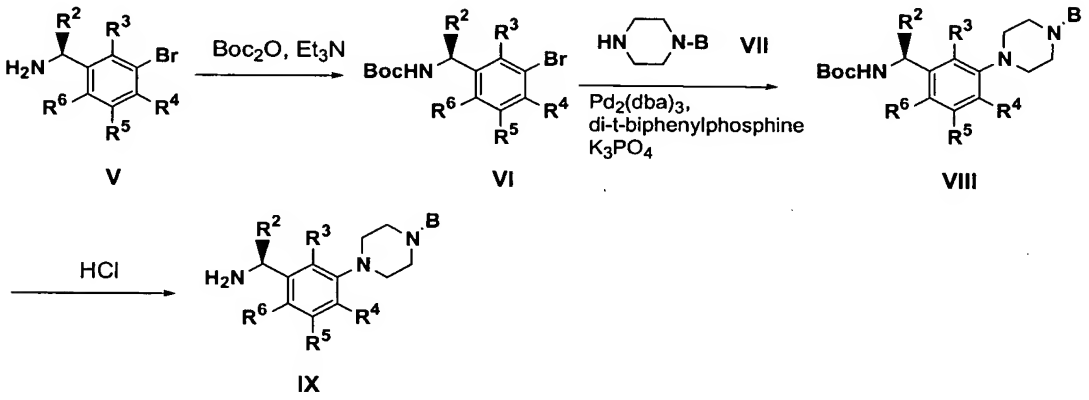
solvent followed by acidification with an appropriate acid such as 1N hydrochloric acid to provide the cinnamic acid of Formula IV.

Reaction Scheme 2



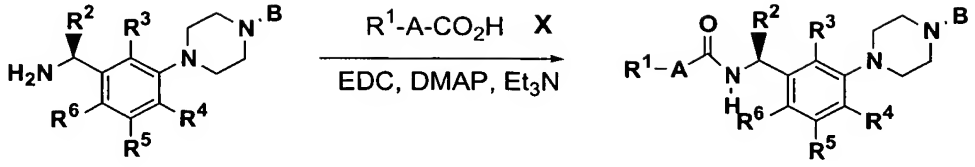
Reaction Scheme 2 depicts an alternative preparation of a cinnamic acid derivative of Formula IV which can be then used to prepare compounds within general Formula I.

Reaction Scheme 3



Reaction Scheme 3 depicts a general method useful for the preparation of amines of Formula IX which are useful intermediates for the preparation of compounds of Formula I. The bromide of Formula V is converted to the compound of Formula VI by treatment with di-t-butyl-di-carbonate and triethylamine. Compound of Formula VI underwent the palladium-catalyzed amination with an amine of Formula VII to provide compound of Formula VIII. Hydrolysis of Formula VIII afforded the amine of Formula IX.

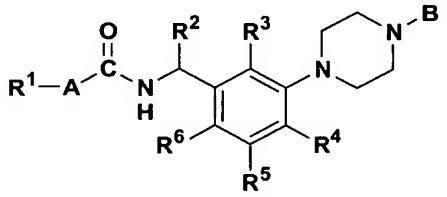
Reaction Scheme 4



IX Id

Reaction Scheme 4 depicts the preparation of compounds of general Formula Id from the acid of general Formula X and amine of general Formula IX. The coupling of the acid, X, and amine, IX is carried out by methodology well known in the art for the conversion of an acid and an amine to form an amide. Useful reactive derivatives of the acid of Formula X include, but are not limited to, activated esters, reactive mixed anhydrides, and acid halides (such as the acid chloride, prepared e.g. with thionyl chloride or oxalyl chloride). A preferred method is to condense the acid of Formula X with the amine of Formula IX in the presence of an appropriate condensing agent, for example, 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide (EDC) or dicyclohexylcarbodiimide (DCC), and a basic tertiary amine, such as 4-dimethylaminopyridine (DMAP), in an inert solvent such as dichloromethane. The more preferred method is to couple the acid of Formula X with the amine of Formula IX in the presence of 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide, hydrochloride (EDC) in the presence of 4-dimethylaminopyridine (DMAP), triethylamine (Et_3N), in dichloromethane.

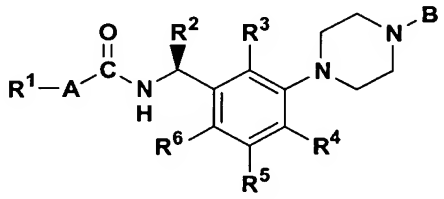
In one embodiment, the present invention includes compounds of Formula I or a pharmaceutically acceptable salt thereof



I

wherein R^1 is selected from the group consisting of pyridinyl, 3-quinolinyl, 2-thienyl, C_{3-6} cycloalkyl and phenyl optionally substituted with substituent independently selected from the group consisting of halogen, C_{1-4} alkyl, C_{1-4} alkoxy, trifluoromethyl and trifluoromethoxy; A is –CH=CH- or $-(CH_2)_n-$; R^2 is C_{1-4} alkyl, CF_3 or hydroxymethyl; R^3, R^4, R^5 and R^6 each are independently hydrogen or fluoro; n is an integer of 1 or 2; and B is 2-pyridinyl, 3-pyridinyl or 4-pyridinyl.

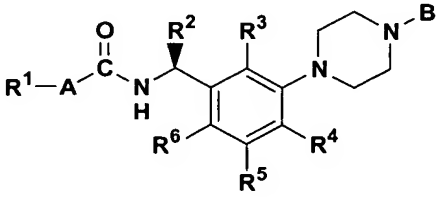
In a preferred embodiment, the present invention includes compounds of Formula Ia or a pharmaceutically acceptable salt thereof



Ia

wherein R^1 is selected from the group consisting of pyridinyl, 3-quinolinyl, 2-thienyl, C_{3-6} cycloalkyl and phenyl optionally substituted with substituent independently selected from the group consisting of halogen, C_{1-4} alkyl, C_{1-4} alkoxy, trifluoromethyl and trifluoromethoxy; A is –CH=CH- or $-(CH_2)_n-$; R^2 is methyl; R^3, R^4, R^5 and R^6 each are independently hydrogen or fluoro; n is an integer of 1 or 2; and B is 2-pyridinyl, 3-pyridinyl or 4-pyridinyl.

In another preferred embodiment, the present invention includes compounds of Formula Ib or a pharmaceutically acceptable salt thereof



Ib

wherein R^1 is selected from the group consisting of pyridinyl, 3-quinolinyl, 2-thienyl, C_{3-6} cycloalkyl and phenyl optionally substituted with substituent

independently selected from the group consisting of halogen, C_{1-4} alkyl, C_{1-4} alkoxy, trifluoromethyl and trifluoromethoxy; A is –CH=CH- or $-(CH_2)_n-$; R^2 is hydroxymethyl; R^3, R^4, R^5 and R^6 each are independently hydrogen or fluoro; n is an integer of 1 or 2; and B is 2-pyridinyl, 3-pyridinyl or 4-pyridinyl.

Preferred compounds for use in the method of the present invention include the compounds of Formula I listed below:

(S)-3-phenyl-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(2-fluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(3-fluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(2,3-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(2,4-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(2,5-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(2,6-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(3,4-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(3,5-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide;

(S)-3-(2,4-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-propionamide;

(S)-3-(3,4-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-propionamide;

(S)-2-(2,5-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide;

(S)-2-(2,6-difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide;

(S)-2-cyclopentyl-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide; and
(S)-2-cyclohexyl-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide;
or a pharmaceutically acceptable salt thereof.

BIOLOGICAL ACTIVITY

KCNQ Methods and Results

Potassium (K^+) channels are structurally and functionally diverse families of K^+-selective channel proteins which are ubiquitous in cells, indicating their central importance in regulating a number of key cell functions [Rudy, B., Neuroscience, 25: 729-749 (1988)]. While widely distributed as a class, K^+ channels are differentially distributed as individual members of this class or as families. [Gehlert, D.R., et al., *Neuroscience*, 52: 191-205 (1993)]. In general, activation of K^+ channels in cells, and particularly in excitable cells such as neurons and muscle cells, leads to hyperpolarization of the cell membrane, or in the case of depolarized cells, to repolarization. In addition to acting as an endogenous membrane voltage clamp, K^+ channels can respond to important cellular events such as changes in the intracellular concentration of ATP or the intracellular concentration of calcium (Ca^{2+}). The central role of K^+ channels in regulating numerous cell functions makes them particularly important targets for therapeutic development. [Cook, N.S., *Potassium channels: Structure, classification, function and therapeutic potential.* Ellis Horwood, Chinchester (1990)]. One class of K+ channels, the KCNQ family exemplified by KCNQ2, KCNQ2/3 heteromultimers, and KCNQ5, is regulated by transmembrane voltage and plays a potentially important role in the regulation of neuronal excitability [Biervert, C., et al., *Science*, 279: 403-406 (1998); Lerche, C. et al., J. Biol. Chem. 275:22395-22400 (2000); Wang, H. et al., *Science*, 282:1890-1893 (1998)].

An opener of KCNQ channels, such as the KCNQ2 and KCNQ2/3 channel opener retigabine, exerts its cellular effects by increasing the open

probability of these channels [Main J., Mol Pharmacol 58(2):253-62 (2000); Wickenden, A. et al., *Mol. Pharm.* 58:591-600 (2000)]. This increase in the opening of individual KCNQ channels collectively results in the hyperpolarization of cell membranes, particularly in depolarized cells, produced by significant increases in whole-cell KCNQ-mediated conductance.

A thallium flux assay was used to detect and characterize openers of KCNQ potassium channels. The thallium assay is generally described in International application WO 02/31508 published April 18, 2002. More specifically, the thallium influx assay to detect compounds that block or open the voltage-gated K^+ channel KCNQ2 is described in Example IV of the published WO 02/31508 application.

For data analysis, the amplitude of the average of the negative controls was subtracted from all wells. The amplitudes of the test compounds were then compared to the value of four standard deviations of the negative control wells. The lowest concentration of a test compound sufficient to generate a signal amplitude greater than or equal to four standard deviations from the amplitude of the negative controls was defined as the minimal active concentration.

For generating EC_{50} values, compounds were serially diluted in 1:3 volume increments to produce a 10 point concentration series. EC_{50} values were calculated by fitting the resulting amplitudes to a single-site logistic equation. EC_{50} was defined as the concentration of test compound required to yield 50% of the maximal response. Maximal response (Maximal opening) was the largest signal amplitude above the negative control generated by any concentration of a test compound.

The following Table 1 contains data which show that compounds of the present invention are openers of the KCNQ channels.

TABLE 1

Example No.	EC_{50} (μM)
3	0.476
10	0.001
11	0.001

Example No.	EC_{50} (μM)
12	0.004
13	0.280
17	0.001

In another embodiment, this invention includes pharmaceutical compositions comprising at least one compound of Formula I in combination with a pharmaceutical adjuvant, carrier or diluent.

In still another embodiment, this invention relates to a method of treatment or prevention of disorders responsive to opening of KCNQ potassium channels in a mammal in need thereof, which comprises administering to said mammal a therapeutically effective amount of a compound of Formula I. Preferably, the compounds of Formula I are useful in the treatment of treatment of migraine or a migraine attack, cluster headaches, bipolar disorder, convulsions, mania, acute mania, epilepsy, anxiety, depression, schizophrenia, functional bowel disorders, stroke, traumatic brain injury, multiple sclerosis, neurodegenerative disorders or alleviating pain such as musculoskeletal pain, post operative pain, surgical pain, inflammatory pain, neuropathic pain such as diabetic neuropathy and pain associated with cancer and fibromyalgia.

For therapeutic use, the pharmacologically active compounds of Formula I will normally be administered as a pharmaceutical composition comprising as the (or an) essential active ingredient at least one such compound in association with a solid or liquid pharmaceutically acceptable carrier and, optionally, with pharmaceutically acceptable adjutants and excipients employing standard and conventional techniques.

The pharmaceutical compositions include suitable dosage forms for oral, parenteral (including subcutaneous, intramuscular, intradermal and intravenous) bronchial or nasal administration. Thus, if a solid carrier is used, the preparation may be tableted, placed in a hard gelatin capsule in powder or pellet form, or in the form of a troche or lozenge. The solid carrier may contain conventional excipients such as binding agents, fillers, tableting lubricants, disintegrants, wetting agents and the like. The tablet may, if desired, be film coated by

conventional techniques. If a liquid carrier is employed, the preparation may be in the form of a syrup, emulsion, soft gelatin capsule, sterile vehicle for injection, an aqueous or non-aqueous liquid suspension, or may be a dry product for reconstitution with water or other suitable vehicle before use. Liquid preparations may contain conventional additives such as suspending agents, emulsifying agents, wetting agents, non-aqueous vehicle (including edible oils), preservatives, as well as flavoring and/or coloring agents. For parenteral administration, a vehicle normally will comprise sterile water, at least in large part, although saline solutions, glucose solutions and like may be utilized. Injectable suspensions also may be used, in which case conventional suspending agents may be employed. Conventional preservatives, buffering agents and the like also may be added to the parenteral dosage forms. Particularly useful is the administration of a compound of Formula I directly in parenteral formulations. The pharmaceutical compositions are prepared by conventional techniques appropriate to the desired preparation containing appropriate amounts of the active ingredient, that is, the compound of Formula I according to the invention. See, for example, *Remington's Pharmaceutical Sciences*, Mack Publishing Company, Easton, PA, 17th edition, 1985.

The dosage of the compounds of Formula I to achieve a therapeutic effect will depend not only on such factors as the age, weight and sex of the patient and mode of administration, but also on the degree of potassium channel activating activity desired and the potency of the particular compound being utilized for the particular disorder of disease concerned. It is also contemplated that the treatment and dosage of the particular compound may be administered in unit dosage form and that the unit dosage form would be adjusted accordingly by one skilled in the art to reflect the relative level of activity. The decision as to the particular dosage to be employed (and the number of times to be administered per day is within the discretion of the physician, and may be varied by titration of the dosage to the particular circumstances of this invention to produce the desired therapeutic effect.

A suitable dose of a compound of Formula I or pharmaceutical composition thereof for a mammal, including man, suffering from, or likely to

suffer from any condition as described herein is an amount of active ingredient from about 0.01 μg/kg to 10 mg/kg body weight. For parenteral administration, the dose may be in the range of 0.1 μg/kg to 1 mg/kg body weight for intravenous administration. For oral administration, the dose may be in the range about 0.1 μg/kg to 5 mg/kg body weight. The active ingredient will preferably be administered in equal doses from one to four times a day. However, usually a small dosage is administered, and the dosage is gradually increased until the optimal dosage for the host under treatment is determined.

However, it will be understood that the amount of the compound actually administered will be determined by a physician, in the light of the relevant circumstances including the condition to be treated, the choice of compound of be administered, the chosen route of administration, the age, weight, and response of the individual patient, and the severity of the patient's symptoms.

The following examples are given by way of illustration and are not to be construed as limiting the invention in any way inasmuch as many variations of the invention are possible within the spirit of the invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Unless otherwise stated, solvents and reagents were used directly as obtained from commercial sources, and reactions were performed under a nitrogen atmosphere. Flash chromatography was conducted on Silica gel 60 (0.040-0.063 particle size; EM Science supply). ^{1}H NMR spectra were recorded on a Bruker DRX-500f at 500 MHz; a Bruker DPX-300B at 300 MHz; or a Varian Gemini 300 at 300 MHz . The chemical shifts were reported in ppm on the δ scale relative to δTMS = 0. The following internal references were used for the residual protons in the following solvents: $CDCl_3$ (δ_H 7.26), CD_3OD (δ_H 3.30) and DMSO-d_6 (δ_H 2.50). Standard acronyms were employed to describe the multiplicity patterns: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), b (broad), app (apparent). The coupling constant (*J*) is in hertz. LC/MS was performed on a Shimadzu LC-10AS liquid chromatograph using a SPD-10AV UV-VIS detector with Mass Spectrometry data determined using a Micromass LC Platform in positive electrospray ionization mode (ESI+). Mass Spectrometry

(MS) data was obtained using a standard flow injection technique on a Micromass LC Platform in positive electrospray ionization mode (ESI+) unless otherwise noted. High resolution mass spectrometry (HRMS) data was obtained using a standard flow injection technique on a Finnigan MAT 900 mass spectrometer in electrospray ionization (ESI) mode. The analytical reverse phase HPLC method is as follows unless otherwise noted: Column YMC ODS-A C18 S7 (3.0 x 50 mm), Start %B = 0, Final %B = 100, Gradient Time = 2 min, Flow rate 5 ml/minutes. Wavelength = 220 nm, Solvent A = 10% MeOH - 90% H_2O – 0.1% TFA, Solvent B = 90% MeOH - 10% H_2O – 0.1% TFA; and R_t in min. Preparative reverse phase HPLC was performed on a Shimadzu LC-8A automated preparative HPLC system with detector (SPD-10AV UV-VIS) wavelength and solvent systems (A and B) the same as above except where otherwise noted.

The following LCMS conditions were employed for the analysis of the compounds of Examples 1–25 and are as follows:

a) YMC Xterra C18 S5 4.6 x 50 mm; 0 - 100% gradient over 3 min; 4 mL/min flow rate.

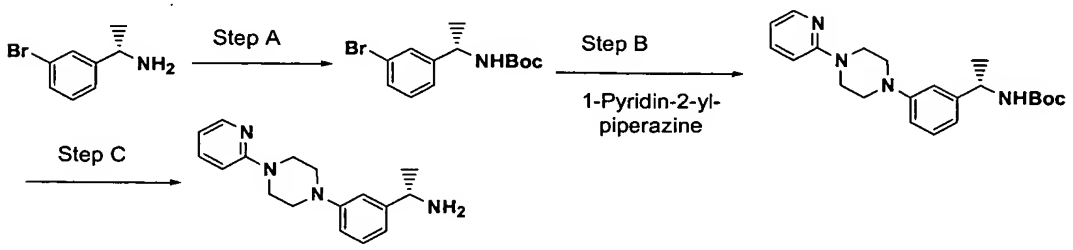
b) YMC ODS-A C18 S5 4.6 x 33 mm, 0 - 100% gradient over 2 min; 5 mL/min flow rate.

SolventA=10%CH_3OH-90%H_2O-0.1%TFA

SolventB=90%CH_3OH-10%H_2O-0.1%TFA

PREPARATION OF INTERMEDIATE

Preparation of *(S)*-1-[3-(4-Pyridin-2-ylpiperazin-1-yl)phenyl]ethylamine



Step A: *(S)*-[1-(3-Bromophenyl)ethyl]carbamic acid *tert*-butyl ester

To a mixture of *(S)*-1-(3-bromophenyl)ethylamine (40.0 g, 200 mmol) and triethylamine (40.5 g, 400 mmol) in dichloromethane (400 mL) was added a solution of di-*t*-butyl-di-carbonate (52.4 g, 240 mmol) in dichloromethane (100 mL). The solution was stirred at room temperature for 2 h. The reaction was quenched with water (100 mL). The organic layer was washed with brine (2 x 250 ml), dried over magnesium sulfate and concentrated under vacuum to the title compound as white solid (61 g).

Step B: *(S)*-{1-[3-(4-pyridin-2-ylpiperazin-1-yl)phenyl]ethyl}carbamic acid *tert*-butyl ester

A mixture of *(S)*-[1-(3-bromophenyl)ethyl]carbamic acid *tert*-butyl ester (5.0 g, 16.7 mmol), 1-pyridin-2-ylpiperazine (10.9 g, 67 mmol), $Pd_2(dba)_3$ (1.55 g, 10 mol%), di-*t*-butyl-biphenylphosphine (0.51 g, 10 mol%), potassium phosphate (7.2 g, 34 mmol) in ethyleneglycol dimethyl ether (40 mL) was refluxed for 4 h. After cooling to room temperature, the reaction mixture was diluted with dichloromethane (100 mL) and the precipitate was filtered off. The filtrate was concentrated under vacuum. The crude product was purified by flash chromatography over silica with ethyl acetate/hexanes (1 : 2) to provide the title compound as an oil (4.1 g, 64% yield).
MS $(M+H)^+$ 383.

Step C: *(S)*-1-[3-(4-Pyridin-2-ylpiperazin-1-yl)phenyl]ethylamine

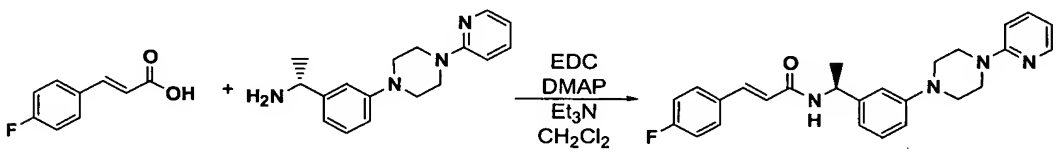
A solution of *(S)*-{1-[3-(4-pyridin-2-ylpiperazin-1-yl)phenyl]ethyl}carbamic acid *tert*-butyl ester (4.1 g, 10.7 mmol) and hydrochloric acid (4N, 11 mL) in dioxane (40 mL) was stirred at 40°C for 5 h. The reaction mixture was concentrated under vacuum, dissolved into water (50 mL), and washed with dichloromethane (2 x 50 mL). The aqueous layer was based with 5N NaOH and extracted with dichloromethane (3 x 100 mL). The combined organic layers were washed with brine (2 x 100 ml), dried over sodium sulfate and concentrated under vacuum to afford the title compound as an oil (2.70 g, 89% yield)..

^{1}H NMR ($CDCl_3$): δ 1.40 (d, 3H), 2.51 (br, s, 2H), 3.32 (t, 4H), 3.69 (t, 4H), 4.11 (m, 1H), 6.61 - 6.70 (m, 2H), 6.82 - 6.86 (m, 2H), 7.00 (s, 1H), 7.20 - 7.26 (m, 1H), 7.46 - 7.51 (m, 1H), 8.19-8.21 (m, 1H).
MS $(M+H)^+$ 283.

EXAMPLES

EXAMPLE 1

(S)-3-(4-Fluorophenyl)-N-{1-[3-(4-pyridin-2-ylpiperazin-1-yl)phenyl]ethyl}-acrylamide

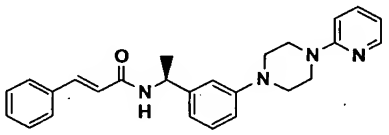
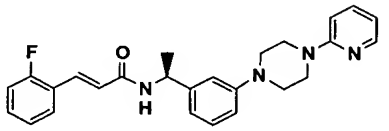
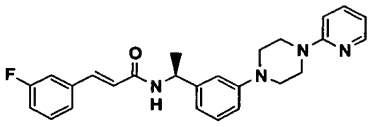
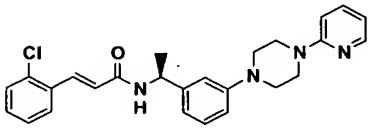
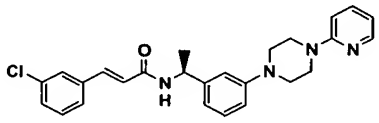
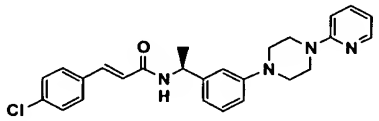


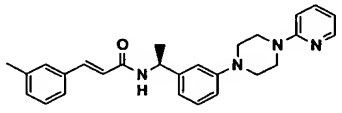
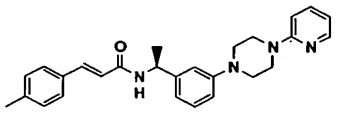
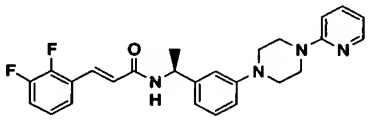
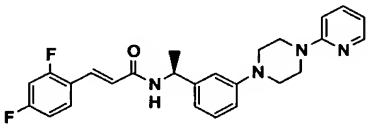
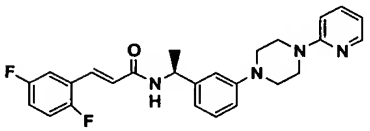
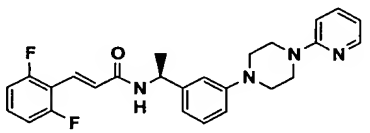
A solution of 4-fluorocinnamic acid (17 mg, 0.1 mmol), *(S)*-1-[3-(4-pyridin-2-yl-piperazin-1-yl)phenyl]ethylamine (24 mg, 0.11 mmol), EDC (28 mg, 0.15 mmol), DMAP (12 mg, 0.1 mmol) and triethylamine (40 mg, 0.4 mmol) in dichloromethane (2 ml) was stirred at room temperature for 14 h. The reaction mixture was purified by flash chromatography over silica gel with ethyl acetate/hexanes (1 : 1) to give the title compound as a solid (26 mg, 60% yield).

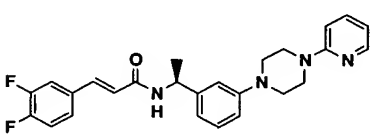
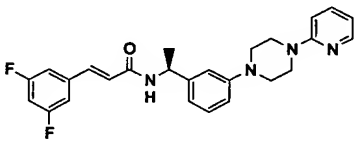
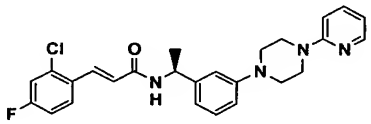
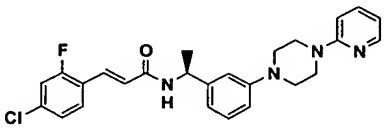
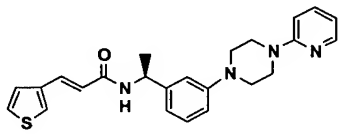
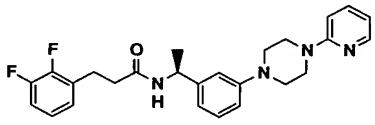
^{1}H NMR (300 MHz, $CDCl_3$): δ 1.55 (d, 3H), 3.30 (t, 4H), 3.68 (t, 4H), 5.23 (m, 1H), 5.86 (d, 1H), 6.29 (d, 1H), 6.65 - 6.70 (m, 2H), 6.86 - 6.89 (m, 2H), 6.96 (s, 1H), 7.00 -7.06 (m, 2H), 7.25-7.29 (m, 1H), 7.42 - 7.52 (m, 3H), 7.59 (d, 1H), 8.19 - 8.21 (m, 1H).
MS $(M+H)^+$ 431.

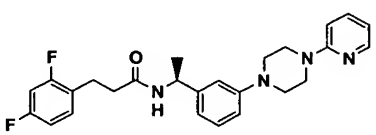
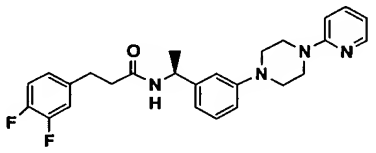
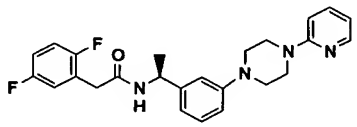
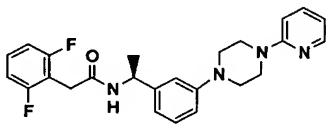
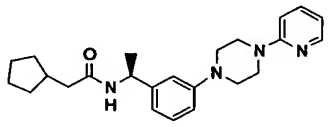
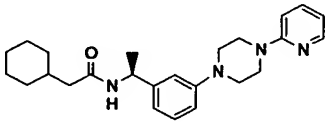
EXAMPLES 2 - 25

Examples 2 - 25 were made from the corresponding appropriate acids using the general method used to prepare Example 1.

Example Number	Structure	Chemical Name	HPLC rt (min) method	Mass $(M+H)^+$ m/z
2		*(S)*-3-Phenyl-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	1.91 (a)	413
3		*(S)*-3-(2-Fluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	1.95 (a)	431
4		*(S)*-3-(3-Fluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	1.97 (a)	431
5		*(S)*-3-(2-Chloro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.09 (a)	447
6		*(S)*-3-(3-Chloro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.19 (a)	447
7		*(S)*-3-(4-Chloro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.16 (a)	447

Example Number	Structure	Chemical Name	HPLC rt (min) method	Mass $(M+H)^+$ m/z
8		*(S)*-N-{1-[3-(4-Pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-3-m-tolyl-acrylamide	2.11 (a)	427
9		*(S)*-N-{1-[3-(4-Pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-3-p-tolyl-acrylamide	2.10 (a)	427
10		*(S)*-3-(2,3-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.06 (a)	449
11		*(S)*-3-(2,4-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.04 (a)	449
12		*(S)*-3-(2,5-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.03 (a)	449
13		*(S)*-3-(2,6-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.00 (a)	449

Example Number	Structure	Chemical Name	HPLC rt (min) method	Mass $(M+H)^+$ m/z
14		*(S)*-3-(3,4-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.07 (a)	449
15		*(S)*-3-(3,5-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.06 (a)	449
16		*(S)*-3-(2-Chloro-4-fluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.19 (a)	465
17		*(S)*-3-(4-Chloro-2-fluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acrylamide	2.23 (a)	465
18		*(S)*-N-{1-[3-(4-Pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-3-thiophen-3-yl-acrylamide	1.81 (a)	419
19		*(S)*-3-(2,3-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-propionamide	1.32 (b)	451

Example Number	Structure	Chemical Name	HPLC rt (min) method	Mass $(M+H)^+$ m/z
20		*(S)*-3-(2,4-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-propionamide	1.33 (b)	451
21		*(S)*-3-(3,4-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-propionamide	1.33 (b)	451
22		*(S)*-2-(2,5-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide	1.22 (b)	437
23		*(S)*-2-(2,6-Difluoro-phenyl)-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide	1.20 (b)	437
24		*(S)*-2-Cyclopentyl-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide	1.26 (b)	393
25		*(S)*-2-Cyclohexyl-N-{1-[3-(4-pyridin-2-yl-piperazin-1-yl)-phenyl]-ethyl}-acetamide	1.35 (b)	407